FUEL CYCLE SIMULATION

A "computational interactive tool-box" tailored to the needs of a wide-variety of potential users is possible

- **Provide high fidelity dynamic simulation of fuel cycles**
  - **Assess technology implications on**
    - **Economics & sustainability**
    - **Safety and environmental issues**
    - **Proliferation & International relations**
  - **Provide technical input to decision makers**
- **Reduce cost of nuclear energy**
  - **New tools for developing and designing innovative technologies**
  - **Shorten the development and deployment time by optimizing systems in a computational domain first**
  - **Reduce uncertainty and R&D cost by reducing the number of expensive large scale experiments**
  - **Perform virtual experiments when physical experiments are too expensive or impossible**
- **Guide the rebuilding of the research infrastructure**
  - **Define experimental data needs and design facilities**
  - **Built facilities to support the most promising future technologies**
  - **Establish a common protocol for data collection, analyses and archiving**
  - **Establish joint university-national laboratory-industry-regulatory agency research projects**

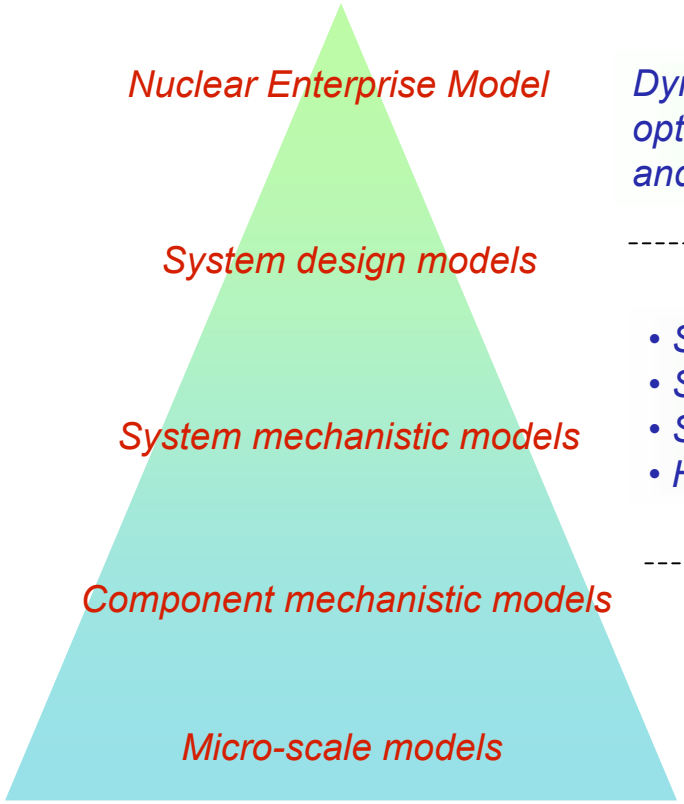
Advanced visualization
- Walk-through models
- Numerical prototyping
- Easy I/O processing

High-fidelity mechanistic models
- Fundamental - first principle models
- Virtual experiments
- Design optimization
- Simpler-cheaper experiments

Fully interactive models
- Coupled phenomenology
- Multi-scale (spatial & temporal), multi-attribute analyses.
- Dominant phenomena

High-speed computation
- Realistic assessment of options
- Tool for decision-makers

A multi-tier, multi-scale and multi-purpose simulation and modeling strategy is possible using the integrated toolbox



Dynamic assessment and optimization of various National and International fuel cycles

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- *System deployment options*
- *System design and assessments*
- *Sensitivity studies*
- *High-fidelity design*

- *First-principle & fundamental modeling*
- *Phenomenological understanding*

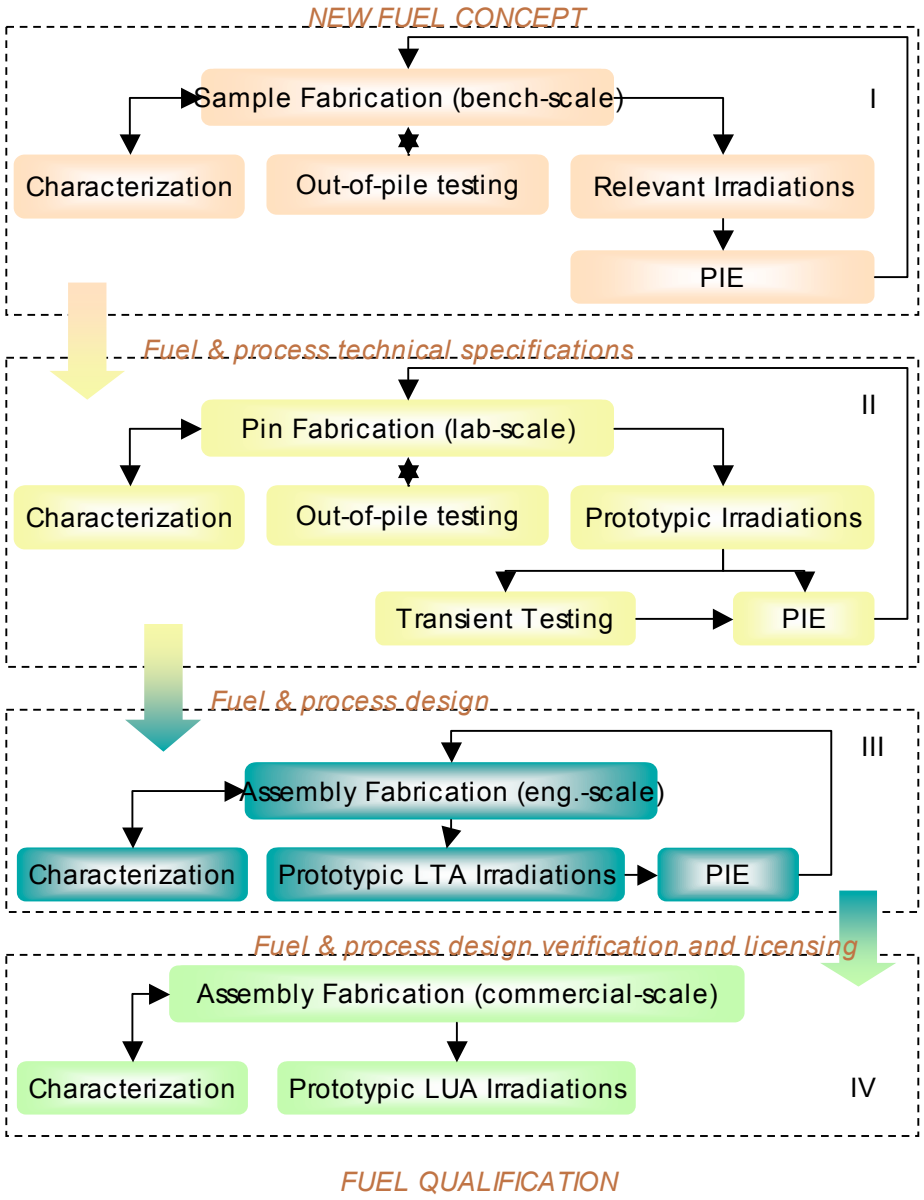
Policy & technology decisions

Design engineering

Engineering Science

Basic Science

FUEL DEVELOPMENT



Currently, new fuels are developed by brute force - mostly empirical

- Currently, fuel performance codes are used to justify irradiation tests - not to design fuels
- Modeling and simulation is not going to replace the development process any-time soon (for at least another 2 decades)
- BUT, modeling and simulation can be used to streamline the process
  - Faster & cheaper development of new fuel types
- The proposed MA-bearing fuels are even more complex than the traditional fuel (UO_2, MOX)

- Develop a complete physical understanding of MA bearing fuel performance using fundamental modeling aided by “targeted experiments”.
  - “targeted verification experiments” should not take a life of their own and cost more than the qualification experiments

- 10-year challenge:

  Develop a computational toolbox to accelerate the fuel qualification process by at least 30%
  - Reduce the time to < 10 years
    - Demonstrate the minimum dataset needed to predict the trends
    - Demonstrate methodology in comparison with the historic UO2-MOX database

- 5-year challenge

  Identify the key experiments needed for any new fuel type (MA fuels) to validate the multi-scale approach at various levels
  - Complete thermo-chemical database for all elements of interest

- Note:

  Fuel development challenges in a closed fuel cycle starts at separations step.

  The development plan using modeling and simulation must be generated jointly.